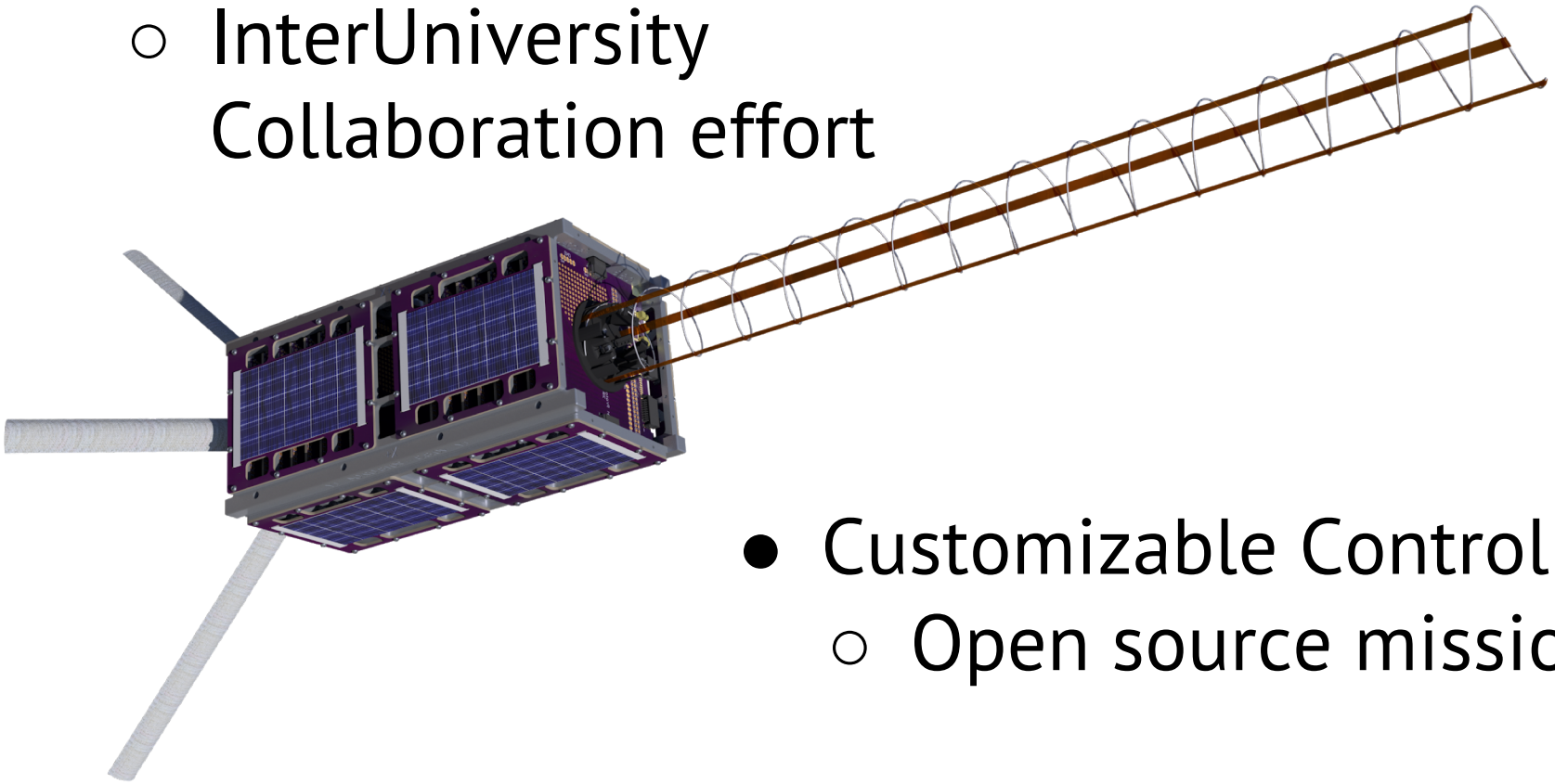
OreSat: Oregon's First Satellite

PSU's Open Source

Space Program

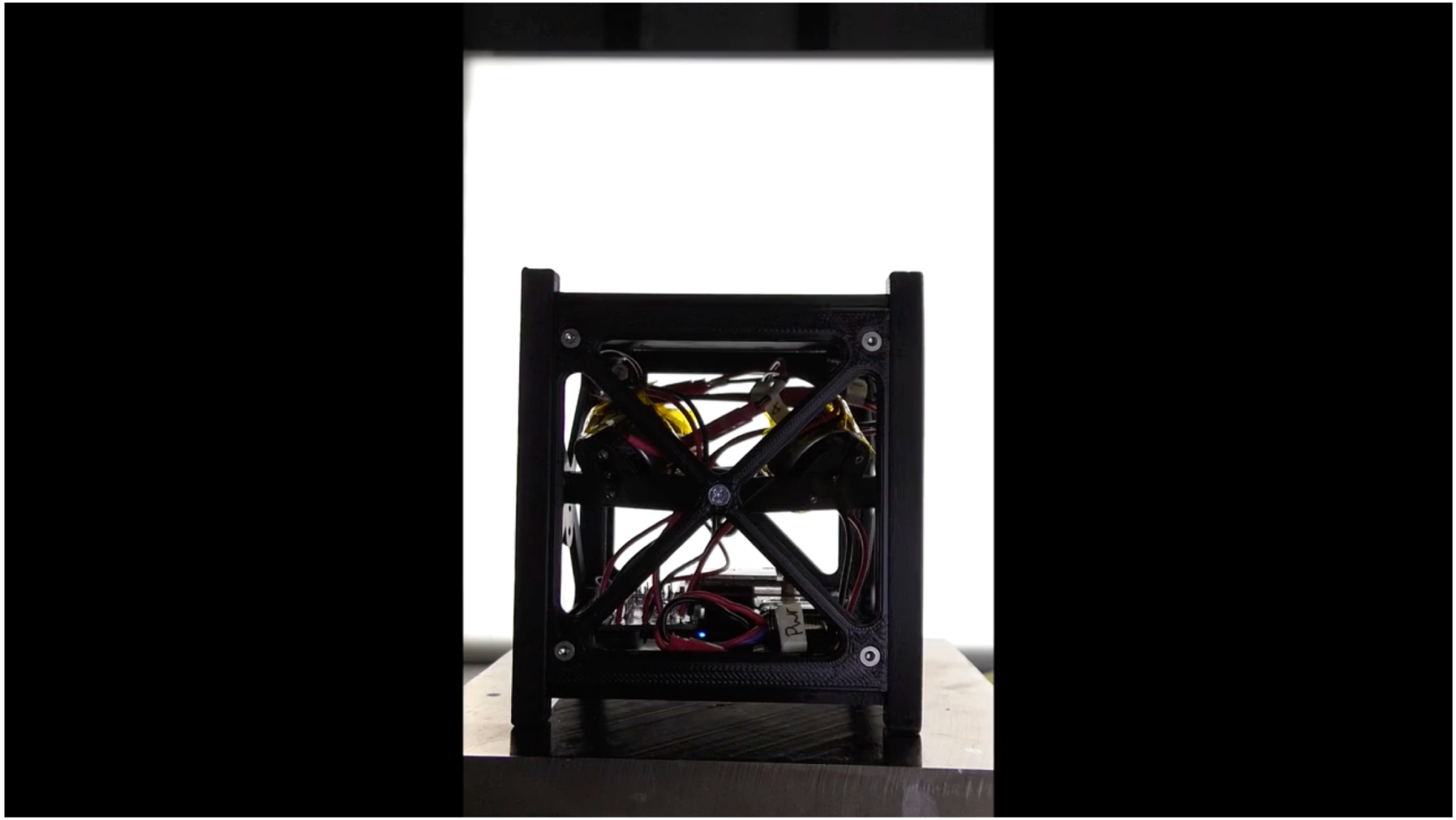
What We're About

- OreSat Open Source Project
  - Public Design Repositories
  - InterUniversity Collaboration effort



- Customizable Controller
  - Open source mission

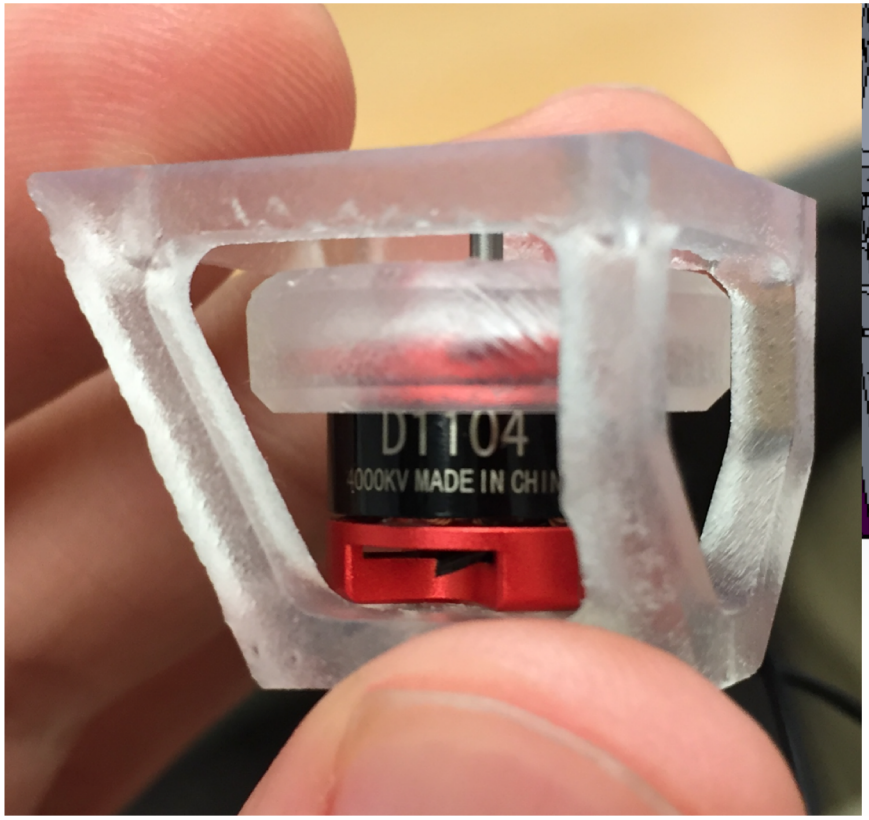
Drop Tower Test

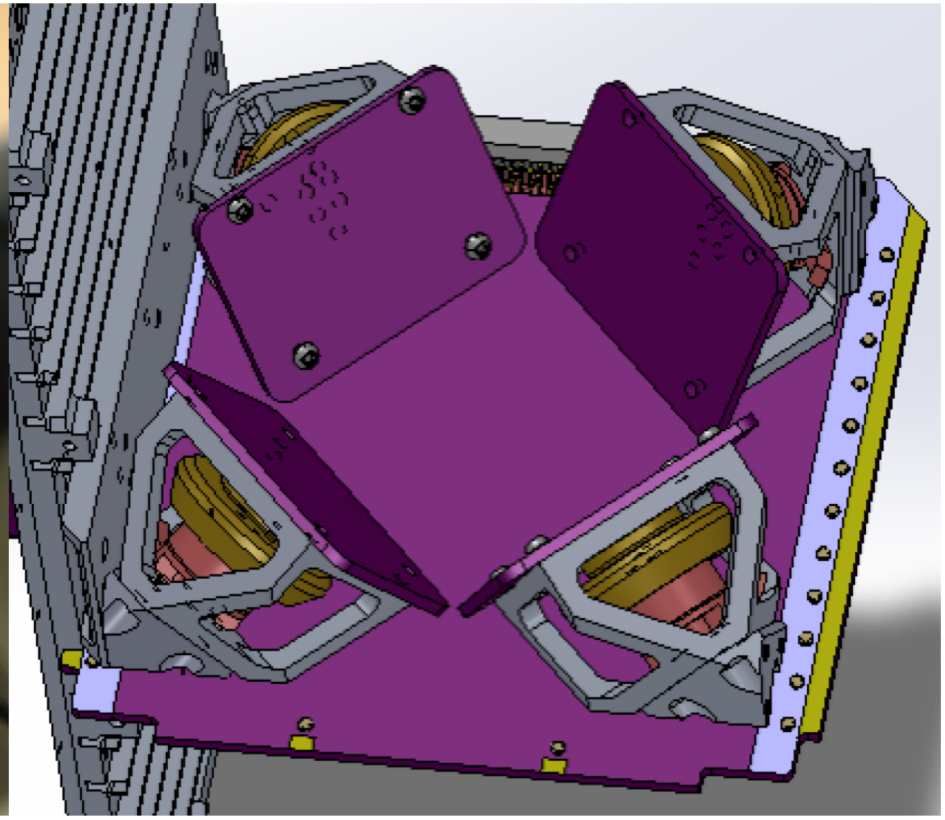


Attitude Control System

- Reaction wheels
  - We want to point the satellite at things so we can take pictures and use DxWifi
  - Need four. Three for 3 degrees of freedom and a fourth for redundancy
- Magnetorquers
  - BBQ roll to disperse heat across the entire system
  - Need three

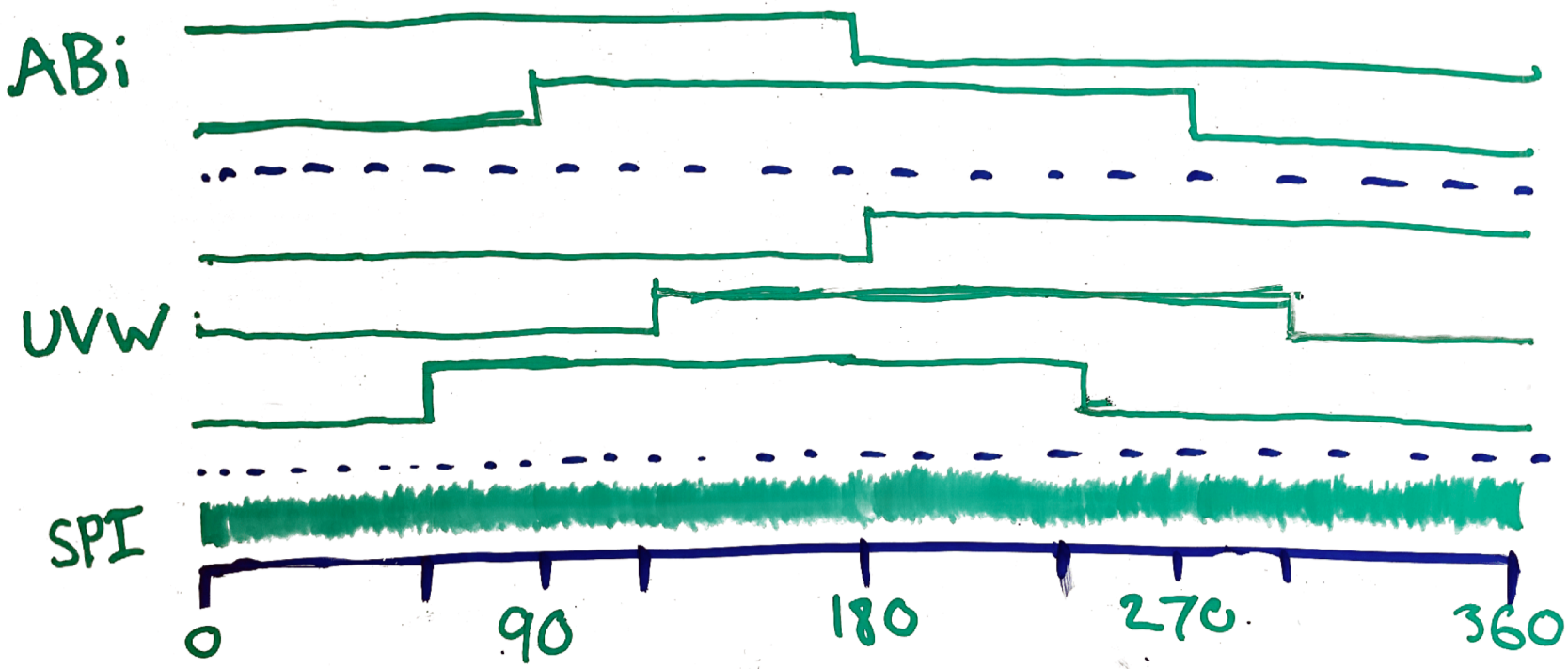
Structural Overview





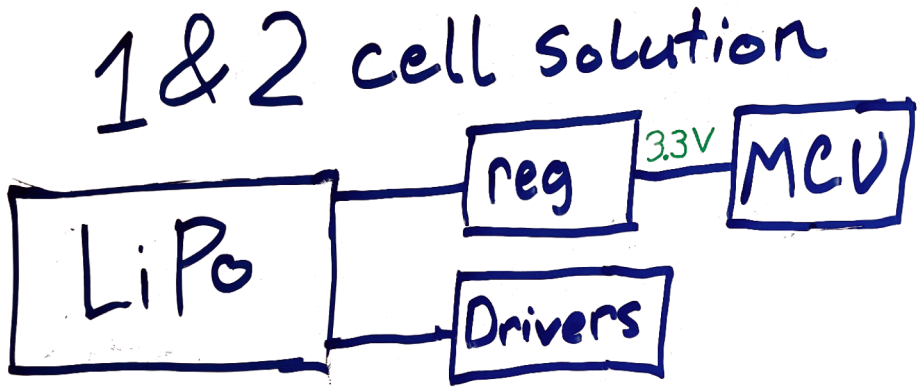
High Functioning Encoder

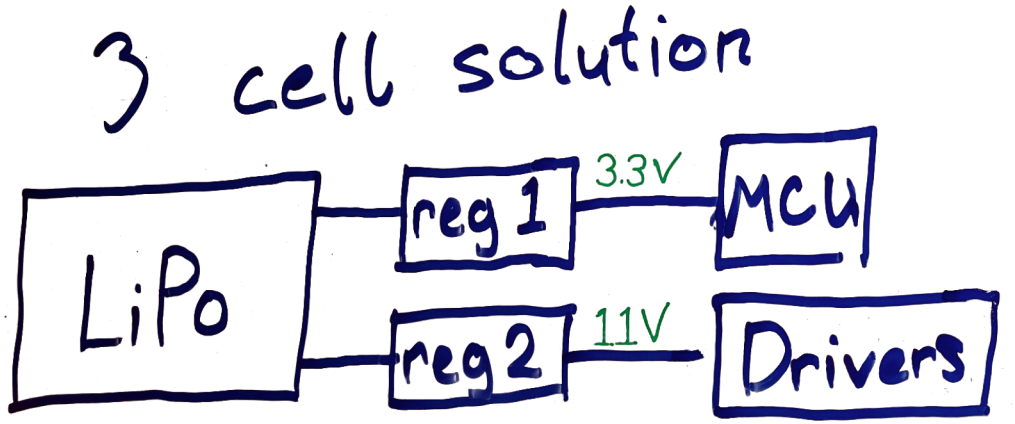
- 14 bit (16k points) precision over spi
- Simulated Hall effect output
- Quadrature Encoding
- No moving parts



Range of Power Input

- Buck Boost Converter
- Motor Driver
- Magnetorquer driver





COTS Systems

- > $5000 per RW
- > $1000 for magnetorquers
- > $5000 for Magnetorquer Controller

Our System

- < $300 per RW
- Estimated < $600 for Magnetorquers + Control
- Total Estimated < $2000

ACS Firmware

- Requirements
  - Open source
  - Easy to maintain
  - Adaptable to a wide range of applications
  - Modular
  - Integrates with OreSat architecture

Existing Solutions

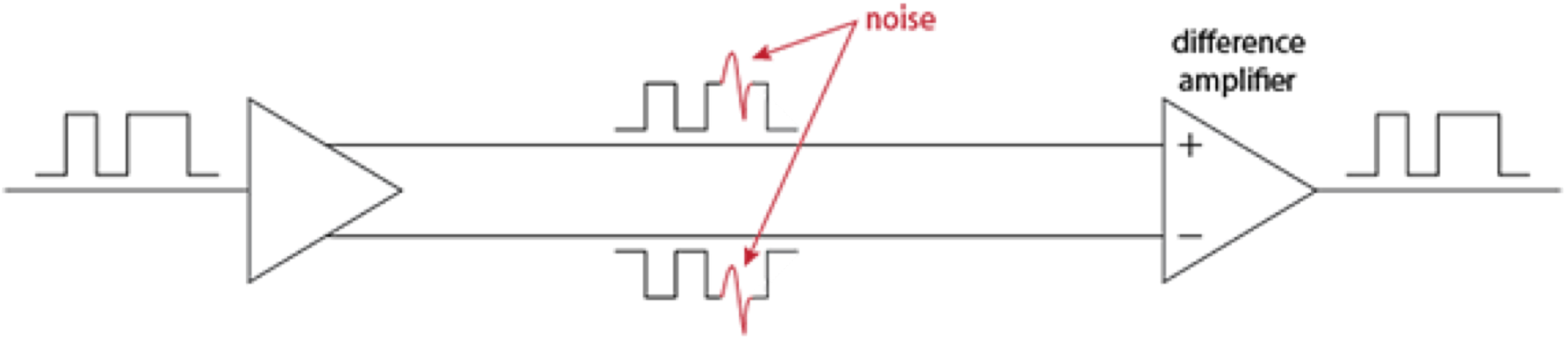
- Reaction wheels
  - Vesc (Benjamin Vedder)
    - Intended for skateboards
      - Skateboards don’t work in space
    - Too complicated
  - SimonK (Standard simple ESC for RC)
    - Basic plug and play
    - Too simple

Our Solution

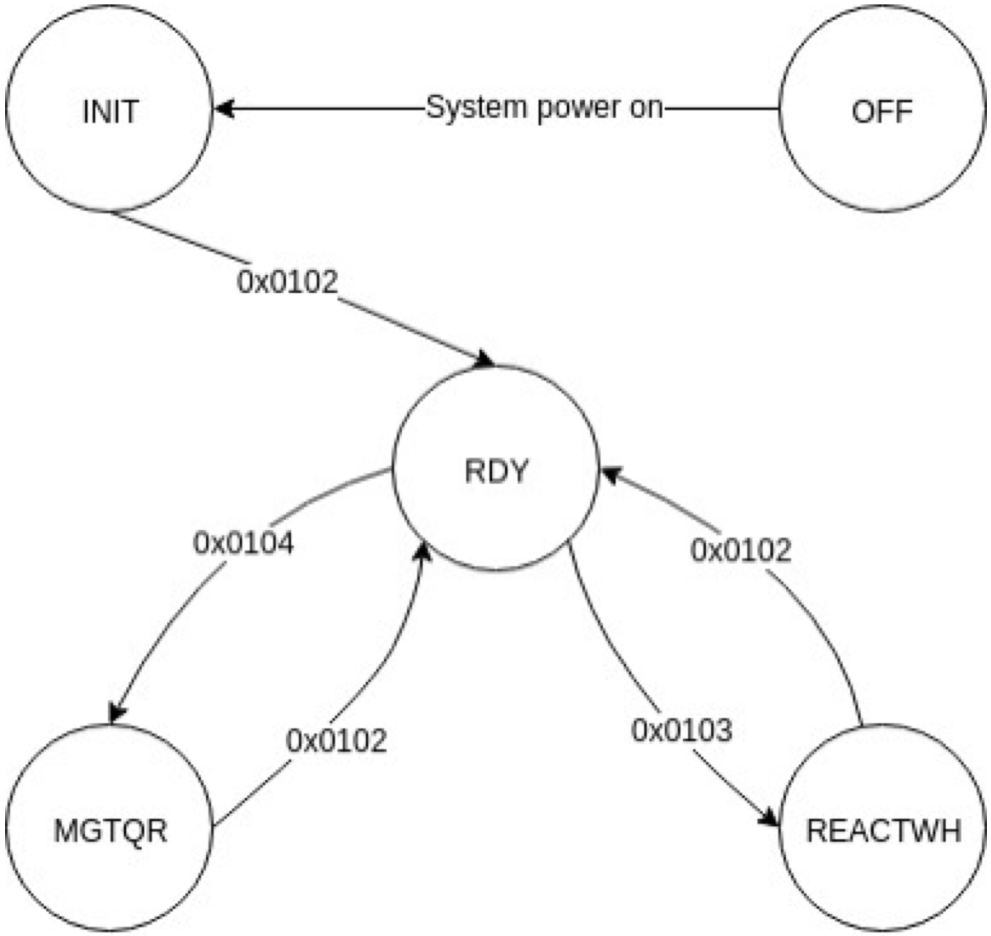
- Custom magnetorquer and BLDC motor control
- Microcontrollers and motor drivers manufactured by STMicroelectronics
- ChibiOS (small OS)
  - Lightweight, open source RTOS
  - Well supported and documented
  - Strong community driving development

Notable feature

- Controller Area Network
  - Reliable communication in noisy environments like space
  - Differential signaling is cool
  - Thanks Miles!



ACS State Machine



ACS State Machine

- System control model
- Adaptable to many applications
- Flexible state table design
  - Allows for easy addition and removal of states
- We want other people to use and improve upon our work.
- Already being ported to other OreSat applications!!!

Microcontrollers

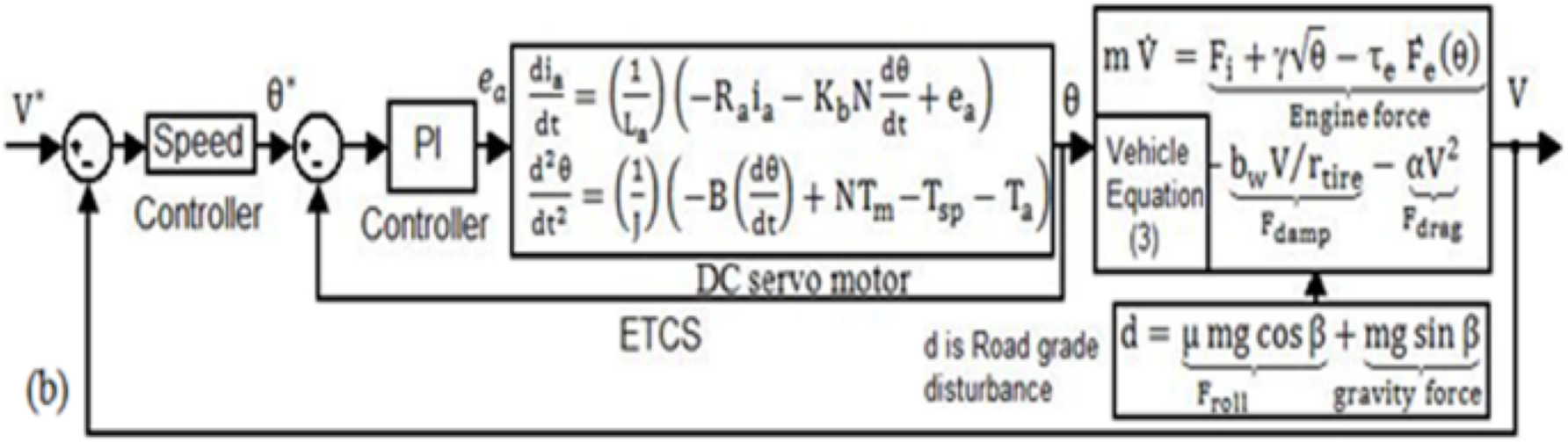
- STM32F042K6 (ARM Cortex-M0)
  - Low power consumption
  - No floating point arithmetic
- STM32L452 (ARM Cortex-M4)
  - This one is awesome!
  - Lower power consumption
  - Faster
  - Yay floating point arithmetic!

Sinusoidal vs FOC

- Sinusoidal
  - Simple method for motor position control
  - Implemented using a duty cycle look up table
  - External control required for velocity
- Field Oriented Control
  - Motor position with current feedback for velocity control
  - Fortunately, proportional-integral-derivative control is a breeze

Proportional-Integral-Derivative Control

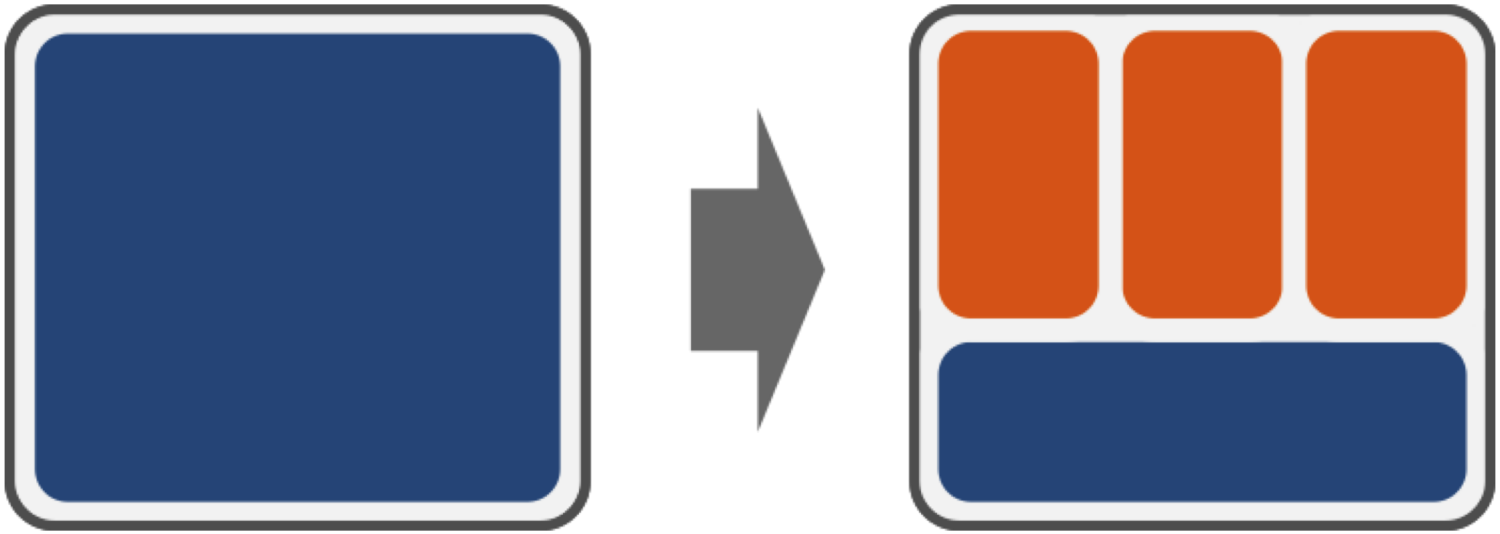
- Automotive example



Our Design Focus

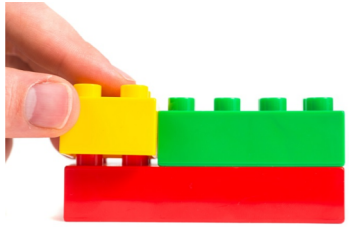
Architecture

rather than **Application**



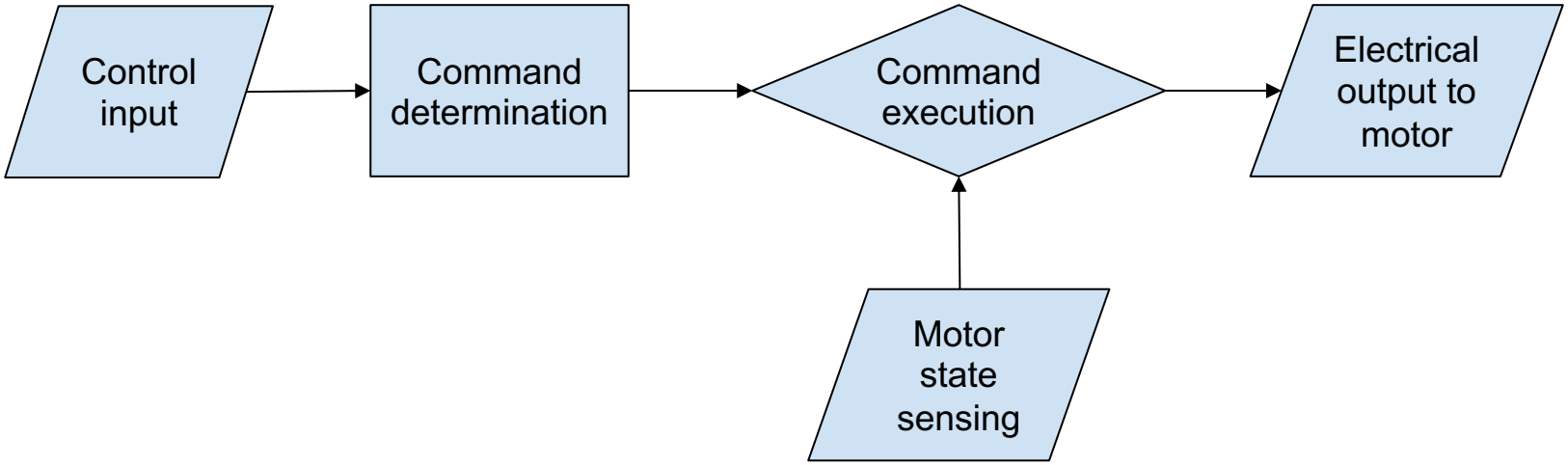
Monolithic **Modular**

Architecture Usability?

- Predictability 
- Modularity 
- Documentation, documentation, documentation 

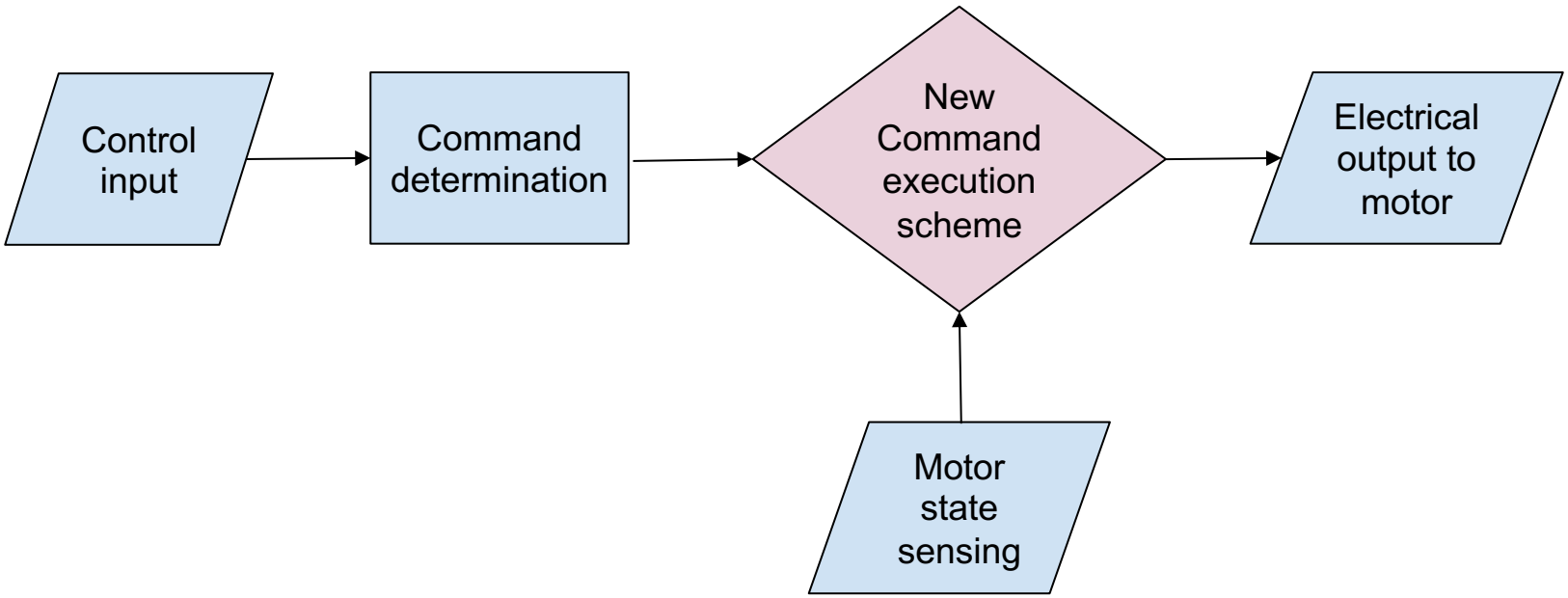
Modularity

Clean and clear abstractions



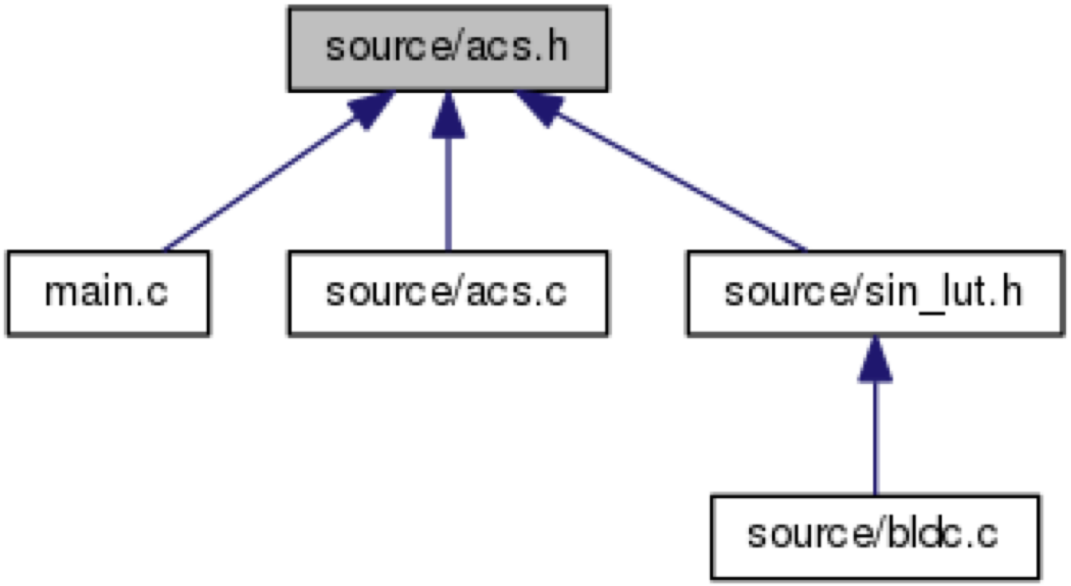
Modularity

Clean and clear abstractions



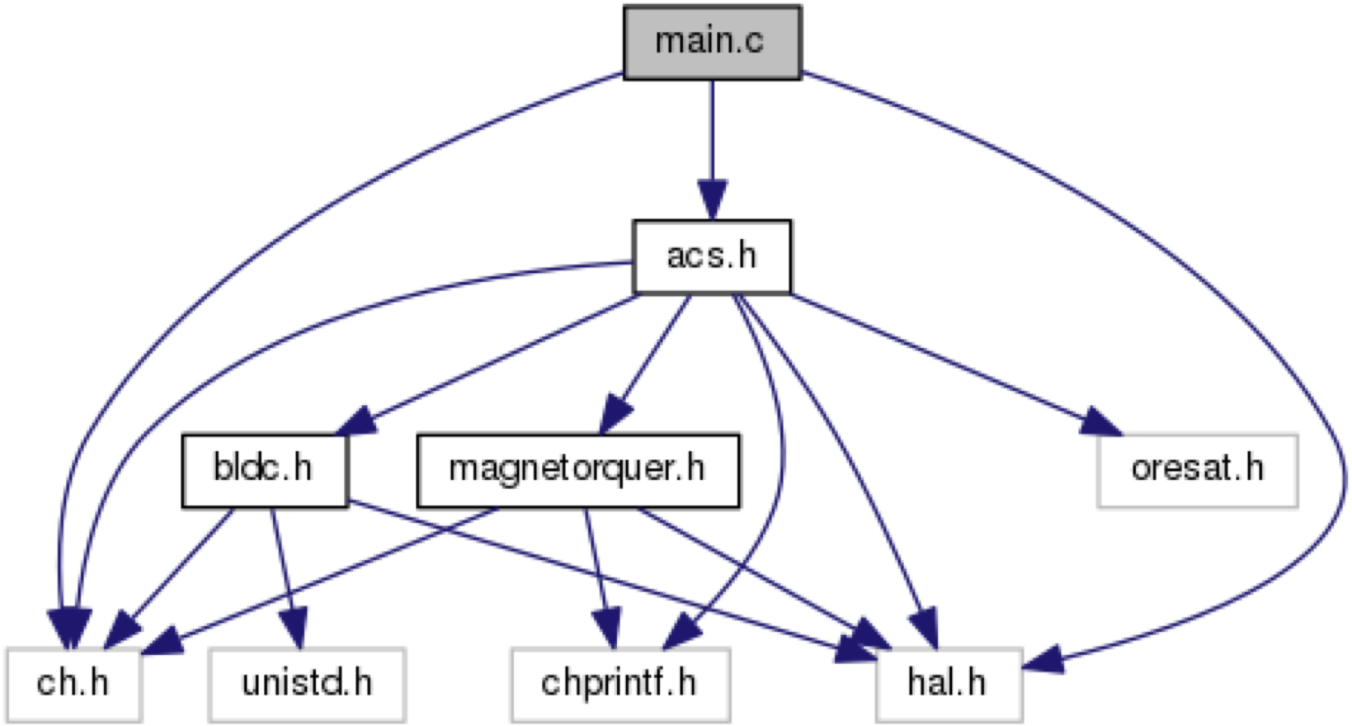
Documentation with Doxygen

Automatic documentation generation

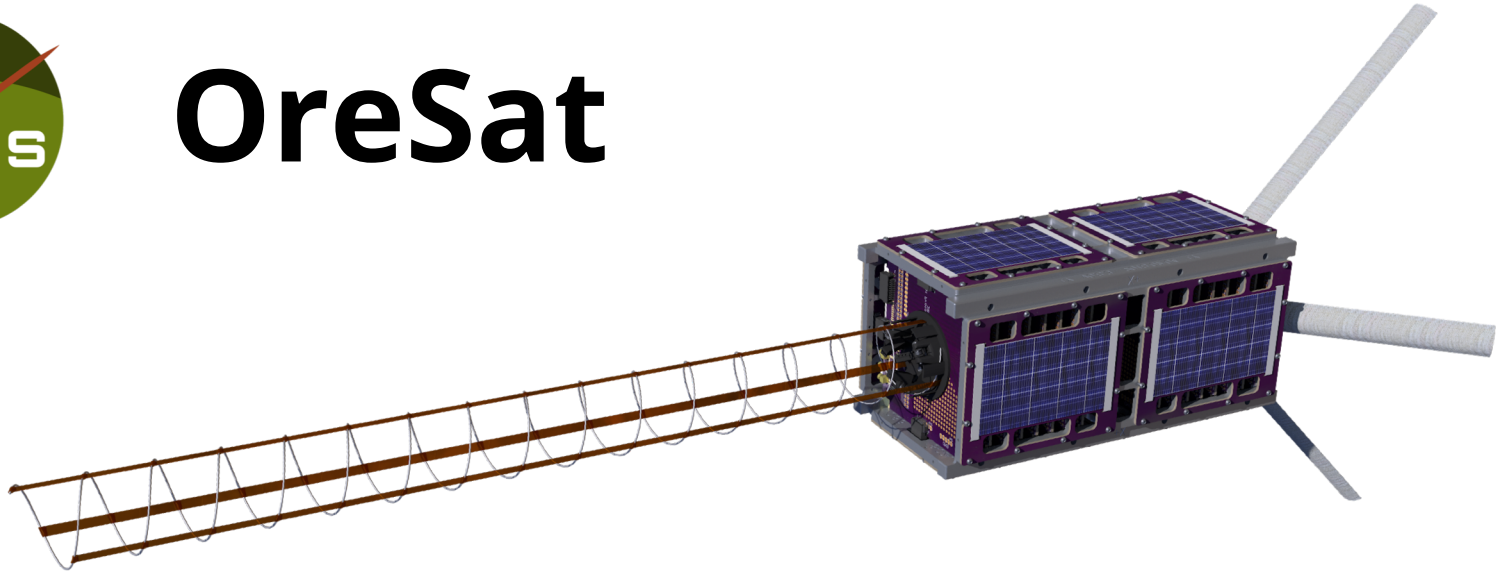


Documentation with Doxygen

Automatic documentation generation



OreSat



- Oregon's first satellite!
- Going to space in 2019/2020
  - Courtesy the NASA CubeSat Launch Initiative

Thank you!

PSAS

Portland State
UNIVERSITY